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(54) METHOD AND APPARATUS FOR JOINING BOARDS

(71) I, WILLIAM ALBERT WOOTTEN, a citizen of the United States of America, of 425 Via Corta, Malaga Cove Plaza, Post Office Box 98, Palos Verdes Estates, California 10274, United States of America, do hereby declare the invention for which I pray that a patent may be granted to me and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates generally to a method of and apparatus for the mechanical joining of panels, e.g. of metal, plastics paper, fibre board, paper board or "liner board", in the assembly and construction of a combination of such panels for the make-up of packages and containers utilized for enclosing articles of commerce, or for use as semi-rigid structural board in the assembly of articles or in the construction of buildings or in the manufacture of vehicles, and to the product.

At present, one generally accepted method for joining flat panels of paper board or fibre board materials to form an "expanded" product that is greater in thickness than the total thickness of the individual panels employed in the make-up of the product, involves the formation of "corrugated board stock" made of coarse fibre kraft material referred to in the trade as "linear board". The product consists of a laminate of three or more board panels comprising a centre corrugated panel joined to two flat panels by adhesive at the apex of each corrugation. The product exhibits rigidity in a direction parallel to the corrugations and is flexible in a direction at right angles to these corrugations. joining flat panels of metal, paper board or gations.

Another generally accepted method for plastics material, to form a product greater in thickness than the total thickness of the individual panels employed in the make-up of the product, is usually referred to as "honeycomb" and is made up of numerous webs arranged in planes inclined with respect to one another and perpendicular to two flat panels, the edges of the webs being attached to the plane surfaces of the two flat panels to form a "sandwich" having uniform or parallel spacing between the flat panels. Normally, the mechanical adjoinment of such "honeycomb" is accomplished by the machine formation of standing internal elements having alternate involute forms or folds that are cut to a length equal to the width of the final assembly and which are combined with final enclosure panels. The product that results is placed between two panels and is laminated between these two panels with the edge standing structure bonded to the inside surfaces of the panels using adhesives or, in the case of metal, welding techniques, thus forming a honeycomb sandwich board. The combination exhibits an isotropic rigidity and is generally inflexible in all directions.

In general usage, boards of the type produced wth "honeycomb" form are utilized in comparatively exotic applications such as, for example, aircraft construction and usually in circumstances where prime weight conditions warrant the expense of this structure which is, at best, difficult to produce. In contrast, the product of the present invention can be produced with simple tooling, can be made to exhibit many of the same structural traits associated with "honeycomb", can be made using less material, and can be made up with convenient and accepted procedures common to the arts of fabricating the specific materials in question.

According to one aspect of the present invention there is provided a product comprising two panels disposed in spaced relation to one another, each of said panels having a plurality of cuts therein defining tabs which are bent relative to said panel to extend toward the other of said panels across substantially the entire space between said

panels, pairs of said tabs extending respectively from said panels being disposed in substantially completely overlapping relation to one another to form intermediary members that retain said panels in fixed position relative to one another.

In contrast to the prior proposals, an embodiment of the present invention achieves a mechanical interlock between two paper board panels through the adhesive attachment of the overlapping tabs which are bent substantially at right angles to the planes of the panels. The use of such tabs achieves a reduction in the amount of paper board or fibre board panel required to manufacture an "expanded" board, and produces a board having rigidity in two directions and exhibiting tension and compression strength comparable to that of a known corrugated board consisting of three sheets. To achieve full enclosure, the outer surface of one panel can be covered by an imperforate overlay panel of light weight material to dress or finish the external surface of a package fabricated from the product. A similar overlay panel can be applied to the opposite face of the board for dress or added strength.

By joining two panels through the agency of tabs which are connected to one another by adhesive, mechanical joining, welding or any other mating procedure, a product can be produced which exhibits tension and compression strength comparable to that of "honeycomb" board but with less material usage and in a form producible by an easier technique compatible with high speed production.

The panels may be provided with tabs of graduated sizes to provide a spacing difference between the panels being joined or to accommodate a contouring of one or both panels with respect to each other or the centre line of the product, as for example, in a boat hull, airfoil, or a tray unit having a recess.

Where high crush strength is required, an overlay panel provided with larger tabs than those of the joined panel may be employed. The larger tabs extending from this overlay panel are forced into the openings of the joined panels in such a way that each enlarged tab element from the third sheet forms a contoured strut completely bridging the space between the original panels and positioned 180° from the previously formed tab connection on the opposite side of the panel opening.

According to another aspect of the invention there is provided a method of forming a structural member comprising the steps of making cuts in a pair of panels to form a plurality of tab areas in each said panel, each cut leaving an uncut portion in said panel which is adapted to act as a hinge line for said tab area said cuts producing like patterns of tabs in each of said panels, positioning said pair of panels in spaced, facing relation to one another with said like patterns of tab areas being in substantially opposing relation to one another, bending the tab areas in said panels about their respective hinge lines to form a pluralty of tabs which extend into the space between said panels, each tab extending from one of said panels being disposed in facing, closely adjacent, substantially completely overlapping relation to a corresponding tab extending from the other of said panels and fastening each tab extending from said one of said panels to the corresponding tab extending from the other of said panels.

The tabs may be bent so as to extend substantially perpendicularly to the planes of the panels. The tabs may extend in a plurality of intersecting planes. Corresponding tabs may be fastened together by adhesive which may be applied to at least one of the panels following the cutting step.

Experimentation has shown that the most rigid structure is obtained when the overlapping tabs are disposed in groups extending in four angular planes, disposed respectively at 45° and 135°, to the longitudinal direction of the panels, thus defining a rhombus or equilateral box-like space by a group of four overlapping tabs.

Unlike the common corrugated board normally produced for the purpose of packaging, box manufacturing and article containment, the board product as above described can provide a maximum strength and rigidity with a minimum amount of material. There is no third "medium" sheet that must be approximately 50% longer than that of the two "linear" sheets employed to retain the corrugated unit. Because of the additional strength imparted to this product by the particular geometry utilized, it is not necessary to use paper weights usually associated with corrugated materials and a lighter paper board stock can be employed with resultant economies.

According to another aspect of the invention there is provided an apparatus for joining a pair of paper or fibre board sheets comprising means for making like patterns of cuts in each of said sheets, said means being operative to make each cut a substantially round arc extending through an angle of at least 180° and not more than 310° whereby each cut defines a substantially round tab area located substantially in the plane of said sheet and adapted to be bent out of the plane of said sheet about an uncut portion which acts as a hinge line, means for applying an adhesive material to the tab areas of at least one of said sheets, means for aligning said sheets in spaced substantially parallel relation to one another with the pattern of cuts in each sheet being in opposed relation to the like pattern of cuts in the other of said sheets, and means

for bending the tab areas defined by the cuts in said sheets through an angle of substantially 90° to the plane of said sheet and in a direction extending toward the other of said sheets to cause corresponding pairs of said tabs extending from said two sheets respectively to come into overlapping, planar engagement with one another in the region between said spaced parallel sheets and to be bonded to one another by said adhesive material.

The tools involved in combining the panels may be like those normally associated with the perforation of a paper board stock. Tooling or holding components used while adhesives set are simply clamping devices.

The combining of the cut panels can be accomplished by hand, particularly if thin panel materials are employed. Under these circumstances, a simple set of suitably sized pins or dowels are placed in a board and arranged in sufficient quantity to be the equivalent of the number of tabs and in the same position with respect to the spacing f the tabs to be joined. A similar dowel board can be used for the second panel and the two units registered so that each pair of opposing dowel elements coincide in a side to side position as they deflect or bend the tabs inwardly, thus causing wetted adhesive coated areas of these tabs to join. After a reasonable amount of time has passed and the adhesive has set, the dowel boards can be opened. The sheets will be joined by the tabs at each point of cutting.

The adjoinment of tabs can be accomplished by other means, as for example, by spot welding in the case of metal, or heat sealing under conditions where a sealant is applied to the material being joined in this configuration. In instances where plastics panels are used, chemical fusing of the tabs to one another can be accomplished by the addition of solvents to the tab faces at the time of connection.

Because of the angular displacement of tabs thus joined together, the two panels are closely united by intermediary members with the plane of one such member being substantially perpendicular to that of another, to produce conditions of maximum strength in the structural arrangement. The doubling of the panels by addition of one or more panel laminations and tab connections gives additional strength together with such rigidity and crystallization properties as may exist in the adhesive employed.

The combining of these two panels with tabs at 90° to the plane of the panels and with the arrangement of these tabs in the form of a rhombus or equilateral parallelogram provides uniform strength characteristics in all directions.

The variation of angular arrangement of the tabs can change the isotropic and uniformly rigid characteristics of this board to anisotropic properties when the angular shape of the parallelogram favours one direction.

EXAMPLE I

The combining of plastics and paper panels can be accomplished by hand, particularly if thin materials are employed. Under these circumstances, a simple set of suitably sized pins or dowels are placed in a board and arranged in number and spacing equal to the number and spacing of tabs. A similar dowel board can be used for the second panel and the two units registered so that each pair of opposing dowel elements coincide in a side to side position as they deflect or bend the tabs inwardly, thus causing wetted adhesive coated areas of these tabs to join. After a reasonable amount of time has passed and the adhesive has set, the dowel boards can be opened. The panels will be joined by the intermediary members at each point of cutting.

An accessory to this operation that is helpful is a section or frame unit disposed between the dowel boards to maintain a specific dimension with respect to thickness and eliminate the necessity for the dowel pins to "bottom out" on the surface of the panel which, as noted earlier, is bearing an adhesive material. This eliminates the tendency of the tooling to adhere to the panel and thus be troublesome.

The production of this type of hand-made board is suitable only for very small applications, panels of thin sheet material and circumstances where tests and laboratory experiments may be desirable.

EXAMPLE II

In circumstances where metal or extremely heavy paper or plastics panels are to be joined and the individual panels are prepared as units, it may be desirable to use one of two types of perforating means; the first being the standard and expensive, male and female punch equipment and, the second, heavy duty die cutting steel bent to the partial cutting circle required and mounted in the conventional flat or rotary cutting unit. This latter type of die cutting procedure is common in the paper board art and would be usable with very light board and even with board of moderate weight.

In the use of metal or heavy weight materials, steel rule die cutting procedures are not adequate and, under these circumstances, conventional tooling in the form of male and female punch and die sets may be required to achieve the desired cuts. Such die cutting procedures are well known and common to the art of cutting heavy stocks, although not usually applied in connection with paper board due to the cost. In order to achieve the desired cuts, it is necessary to

form the cutting face of the punch with an angular contour to permit penetration of the stock in a shearing action which limits the cut so that a section remains uncut to later provide a hinge for the tab when deflected.

In the preferred embodiment of this invention, a punch of the foregoing type can be used in conjunction with a tough resilient material, such as rubber or plastics, of for example, 60 shore so that an effective punching or cutting is made in the sheet without completely passing through it. The rubber or plastics material constitutes a back-up for the punch and offers just enough resistance to provide a clean cut.

In the forming of heavy board stocks that probably would be handled in sheets, it is presumed that large tabs and comparatively heavy thicknesses of finished board is the objective. With board thicknesses of the order of one to two inches and the panel stock making up these boards being as much as one quarter of an inch in thickness, the tabs can be an inch or an inch and one half in diameter. With paper board cut in this fashion, the resistance to bending is considerable and, even with suitable pre-scoring, after the application of the adhesive, it will be essential to use some form of hydraulic or compressed air actuated pin board or button board, preferably made from a flat steel block with dowel pins inserted or a cast aluminium block with button forms on its face coinciding with a similar block to provide the strength and pressure required for the deflection of the tabs and to retain them during adjoinment e.g. until adhesive has been set by heat or other means.

In the formation of steel and metal stocks generally, after punching employing the previously described heavy duty male and female die equipment, similar reciprocating die elements in the form of pin or button plate units coinciding with the tabs in the panels being joined are required to deflect the tabs and prepare the panels for adjoinment. This operation takes place in several steps, the first being the deflection of the tabs by the placement of the panel over a perforated female die plate and forcing pins through the cuts to bend the metal and place the tabs in a partially erect position. With this accomplished in both panels, the second step is to adjoin the button or pin plates which have been forced into the two panels in registry, thus engaging the plates face to face in a common relationship with the tabs adjoined but not connected.

In the final steps of this process, the punching function, to connect the area tab surfaces, is accomplished in an operation wherein one line of tabs is joined at once and the tabs of a given plate assembly are joined at the same time.

In spot welding, it is desirable to weld progressively one or more connections to avoid the current consumption associated with the mass welding of the entire series simultaneously. This is accomplished by utilization of circuitry to intermittently switch from from one welding station to another as is common in certain steel fabricating procedures.

EXAMPLE III

In the assembly of metal, plastics or paper board structures constructed in accordance with the present invention, it is frequently desirable to utilize continuous machinery and to employ roll stock. Under these circumstances, conventional roll handling equipment normal to the utilization of webs is employed. It is customary with machinery of this type to use unwind equipment and web guide devices to maintain the directional movement of the sheet stock continuously and in alignment with follow-on units.

The specific apparatus required for the handling of metal, plastics and paper board is common and widely used in the industry related to each material. In the application and converting of all three material forms two or three separate operational stations in the processing line are required. The first of these provides the function of cutting the tabs in two panels of stock simultaneously, and in synchronization, so that a second station or roll stand holding peripherally mounted pins on cylinder faces can be employed to bend the cut tabs and cause them to adjoin with one another between the panels. In the case of paper, plastics and other comparatively soft and resilient materials, bonding agents in the form of adhesive or thermoplastic pre-coated materials can be employed. However, in the utilization of metal panel assemblies, welding techniques, such as spot welding, brazing and the like should be used.

Even the lightest gauge metals tend to remain in position after upsetting of the tabs and their adjoinment to one another, unlike the more resilient products such as plastics and paper. It is thus possible to follow the punching and bending equipment, in the case of metal, with a third rotary welding function in which the rolls employed are insulated members and the pin elements, which are also insulated, are faced with conductive points that, upon closing aganst the tab surface from opposite directions and through the surface of each panel function to complete an electrical circuit, thus fusing the two planes together by spot welding. Such equipment and apparatus, circuits and devices are common to the metal fabricating art.

The board may include a third panel with cuts slightly larger in diameter than those in the two previously assembled panels. After

formation of these larger cuts, this third panel is attached to the previously assembled panels, and its tabs are forced through the existing openings with the result that the larger tabs each assume a partial cylindrical configuration and, because of the greater length between the hinge point and the extremity of the larger tab (due to its larger diameter) a slight bend is made in the free edge portion of the tab parallel to the plane of the opposite panel, thus affording a connection between the third panel and the opposite panel of the previously joined pair. The contoured or partial cylinder configuration of these tabs adds to the board rigidity in compression and the tabs form struts between the panels and within the confines of the openings in which the first intermediary member is provided.

In order that the present invention may be better understood there will now be described some embodiments thereof, given by way of example only, reference being had to the accompanying drawings in which:

Figure 1 is a perspective view of the two components of a preferred embodiment of product of the present invention.

Figure 2 is a perspective illustration of the two components of Figure 1 illustrating the second step in the preparation of the embodiment of product of this invention;

Figure 3 is a perspective illustration showing the two components with a third cover panel to be applied thereto;

Figure 4 is a perspective illustration of the assembled configuration of a preferred embodiment of this invention with a single cover panel;

Figure 5 is a perspective and exploded illustration of the components of the preferred embodiment including two cover panels;

Figure 6 is an enlarged and cutaway view of a portion of the preferred embodiment of this invention;

Figure 7 is a perspective illustration of an assembled section including two cover panels;

Figure 8 is a perspective illustration of the components of a second embodiment of this invention;

Figure 9 is a perspective illustration of the components of the second embodiment preparatory to assembly;

Figure 10 is a cutaway perspective illustration of a portion of the second embodiment of this invention;

Figure 11 is a cross-sectional cutaway view illustrating a cutting means to accomplish the cuts defining the tabs of the preferred embodiment of this invention;

Figure 12 is a plan view of a cut panel with a coating of adhesive thereon for use in making up an embodiment of the invention;

Figure 13 is a plan view of a cut panel superimposed over a second panel, the cuts in which are shown in dotted line for use in making up an embodiment of the invention;

Figure 14 is a cross-sectional view of a jig for use in the assembly of an embodiment of the present invention;

Figure 15 illustrates the angular relationship of the components of the pin jig of Figure 14;

Figure 16 illustrates a continuous assembly apparatus, employing cylinder units for use in making up an embodiment of the invention;

Figure 17 is a cross-sectional enlarged view of pins of the jig of Figure 14 illustrating the adjoinment of the tabs in the preferred embodiment of this invention;

Figure 18 is an enlarged and partially cutaway perspective illustration showing the adjoinment of the tabs of the preferred embodiment of this invention and the positioning of the tabs with respect to the pins of the apparatus of Figure 16;

Figure 19 is a perspective illustration of the preferred embodiment of this invention;

Figure 20 is a perspective partially cutaway illustration of two tabs during assembly of the second embodiment of this invention, the tabs have been placed adjacent to one another but not adjoined;

Figure 21 is a cross-sectional illustration showing a manual method of adjoinment of the tabs of the second embodiment of the invention;

Figure 22 is a perspective partially cutaway illustration of the adjoined tabs of Figure 20;

Figures 23 to 27 illustrate portions of an apparatus for use in manufacturing the embodiment of the present invention;

Figure 28 is a perspective illustration of an embodiment of this invention;

Figure 29 is a cross-sectional illustration of a further embodiment of this invention;

Figure 30 is a perspective illustration showing the embodiment of Figure 29;

Figure 31 is a perspective illustration of another embodiment of the invention;

Figure 32 is a perspective illustration of an article utilising an embodiment of this invention;

Figure 33 is a perspective illustration of a portion of another article utilising an embodiment of the invention;

Figure 34 is a perspective illustration of a cylinder utilising an embodiment of the invention;

Figure 35 is a perspective and cross-sectional view in cutaway of a further article using an embodiment of the invention;

Figure 36 illustrates in cross-section a ceiling panel, produced in plastics of translucent material, that serves as an exhaust opening of air passage from a plenum, light

transmission and diffusion device, while exhibiting acoustical properties and is constructed according to the invention;

Figure 37 is a disassembled perspective illustration of the components used in making up a further embodiment of the invention;

Figure 38 is a perspective illustration and cutaway showing the product according to the invention made from the components of Figure 37;

Figure 39 is a perspective illustration of an additional embodiment of this invention;

Figure 40 is a cross-sectional view of a die for use in making up the embodiment of Figure 39;

Figure 41 illustrates, in perspective, the assembly of a combination paper board and wood product, such as a door or wall panel using this invention;

Figure 42 illustrates in perspective a partially assembled embodiment of this invention;

Figure 43 is an enlarged perspective view of a portion of the embodiment of Figure 42;

Figure 44 illustrates an apparatus for connecting together or staking metal tabs in the assembly of an embodiment of this invention;

Figure 45 illustrates the second or completed assembly step in the apparatus of Figure 44;

Figure 46 illustrates another apparatus, in an initial position, used in the assembly of Figure 46 in its final position;

Figure 47 illustrates the apparatus of an embodiment of the invention;

Figure 48 illustrates a spot welding technique for the attachment of metal tabs of an embodiment of this invention; and

Figure 49 illustrates a spot welding technique for use in assembling another embodiment of this invention.

Referring now to the drawing, Figure 1 illustrates the two paper, metal, or plastics 1 and 2 used to make an embodiment of the present invention, the panels being perforated respectively at 3 and 4 by cuts. As illustrated, the cuts are not closed so that a hinge line is provided about which a tab defined by each cut can be bent perpendicular to the plane of each panel. The uncut hinge lines, in each panel, extend at different angles to the centre line of the panel, as illustrated, so that each group of four hinge lines, when extended (as shown in broken line in Figure 12), form a rhombus or equilateral parallelogram. The panels 1 and 2, when fabricated of paper or fibre board, range in thickness from 0.005" to 0.250". The shape of each cut is preferably round or circular, and the cut subtends an angle of at least 180° but not more than 310°.

Figure 2 illustrates the panels 1 and 2 of Figure 1 disposed in parallel relation to one another, with their respective tabs 3 and 4 deflected or bent inward about their hinge lines to positions perpedicular to the planes of the panels, and with the tabs being aligned with one another in pairs so that the inner face of each tab 3 is parallel to the plane of the inner face of a corresponding tab 4. As depicted in Figure 2, the planes of the tabs extending from each panel are angularly disposed to one another, due to the aforementioned angular positioning of their respective hinge lines. The arrangement is such that, considering a group of four tabs extending from the plane of a panel, two of the tabs are in planar facing relation to one another along two opposite sides of a rhombus or parallelogram, and the remaining two tabs in said group are similarly in planar facing relation to one another along the other two opposing sides of said rhombus or parallelogram.

Figure 3 depicts the panels 1 and 2 in association with a third and imperforate panel 5 intended to be adhesively secured to the outer face of panel 2 for the purpose of closing the openings in panel 2 left by the tabs 3.

Figure 4 illustrates the panels of Figure 3 in an assembled configuration. Panels 1 and 2 are joined to one another by their tabs 3 and 4 respectively with the tab inner faces being adjoined by adhesive 6. Each tab extends substantially completely across the space between panels 1 and 2, in substantially completely overlapping relation to a tab extending from the other panel. The finishing panel 5 is bonded to the surface of panel 2 to close the openings 7 left by the tabs 3.

Figure 5 is an exploded or separated view of four panels. Panels 1, 2 and 5 have already been described with reference to Figures 1 to 4. An additional imperforate panel 8 is provided for additional coverage and for the purpose of closing openings 9 in panel 1 left by the tabs 4.

Figure 6 is a cutaway view in perspective of panels 1 and 2 showing an intermediary member formed by the adjoinment of two corresponding tabs 3 and 4.

Figure 7 illustrates the completed board structure produced by final assembly of the panels described with reference to Figure 5. Panels 1 and 2 are adjoined by tabs 3 and 4 that are bonded together by adhesive 6 to retain these panels in their proper relationship one to another. Cover panels 5 and 8 are added to provide a smooth and finished surface on both planes of the completed board structure.

Figure 8 illustrates the components of a second embodiment of the invention. Two panels 10 and 11 have been cut as in Figure 1, with the open cuts 12 and 13 being aligned

with one another as earlier described. This second embodiment employs a variation in the cutting arrangement. In this configuration, a closed cut is made in the exact centre of each open cut in one panel. A smaller but identical open cut is made in each open cut of the other panel. The dimensions of the smaller open cuts are 0.005" to 0.010" larger than the diameters of the smallest closed cuts. The two panels are joined by the deflection of the tabs as is done in the preceding embodiment but an additional step achieves a mechanical coupling of one tab with the opposite tab, the intent being to eliminate the adhesive associated with the preceding embodiment. More particularly, inside the tab areas 12 in panel 10 there are provided second open cuts 14, which serve to form additional tabs adapted to engage in openings 15 provided by the closed cuts in tabs areas 13 of panel 11. The adjoinment of the tabs 14 in openings 15 provides the mechanical interlocking of the main tabs 12, 13 and establishes the thickness of the combined panels to achieve the expanded configuration and all of the advantages associated with the preceding embodiment, but without the adhesive requirement.

Figure 9 illustrates the two panels of Figure 8 preparatory to their adjoinment to one another. The tabs 12 and 13 have been deflected into common planes respectively so that their backs can be aligned when the panels 10 and 11 are moved into finished assembly position.

Figure 10 illustrates a pair of assembled tabs 12, 13 of the panels 10 and 11 of Figures 8 and 9 showing how the tabs are connected to one another. The tabs 12 and 13 are aligned, and the internal tab 14 of tab 12 has been forced through the opening 15 of tab 13 to achieve an intermediary member retaining panels 10 and 11 mechanically without the use of adhesives.

Figure 11 is a cross-sectional illustration showing a cutting means for producing an open cut, i.e. a cut which leaves an uncut hinge line about which the tab may be deflected. Each cut is produced by the lower portions of an angular or contoured face of a pin 20 which is pressed against and through the surface of a panel 21 into a resilient back-up member 22, the latter being rubber or a form of plastics material of hard shore having a resilient memory property. The uppermost end of the angular cutting face is located adjacent the upper surface of panel 21 when pin 20 assumes the cutting position shown in Figure 11, to leave the sheet portion adjacent thereto uncut.

Figure 12 illustrates a panel as already described with reference to Figure 1, and its cuts 4, with adhesive stripping, or a partial coating of the tab areas, depicted by the shaded areas 23. It should be noted that the adhesive has been applied prior to deflection of the tabs about their hinge points.

Figure 13 is a plan illustration of a superimposed pair of panels as shown in Figure 12. The panel as shown in Figure 12 has been rotated through 180° so that its top edge, as illustrated in Figure 12, is the bottom edge as shown in Figure 13 and provides the panel 1. It has been laid above a second sheet 2 similar to sheet 1 and which can be coated with adhesive as in Figure 12 or which may remain uncoated. The tabs 3 of panel 2 are shown in dotted line to adjoin tabs 4 of panel 1 with a space existing between the two sheets so that the adhesive cannot prematurely bond the panels.

Figure 14 is a cross-sectional view of an apparatus for assembling the panels of Figure 13 following partial perforating and the application of adhesive. The apparatus includes a pair of registration pins 24 adapted to properly align a pair of retaining plates 25 which, in turn, hold tab positioning pins 26 operative to deflect the tabs 27 of panels 1 and 2 about their respective hinge lines. The action of this deflection is such that the tabs are joined in back to back relation with the adhesive therebetween bonding one tab to another.

Figure 15 is a plan view illustrating the positioning of pins 26 in the apparatus of Figure 14, and the critical spacing in the relationship of these pins to the tabs of sheets 1 and 2. The pins achieve deflection of the tabs and their retention in place adjacent one another during bonding. The pins 26 are smaller in diameter than the tabs and pass easily through the openings to deflect the tabs so that they are disposed within the space 28 existing between each pairs of pins. The width of space 28 is equal to the sum of the thicknesses of the two panels or two tabs. The centre line of each pin 26 is offset slightly as at 29, relative to the centre line of the punch 20, see Figure 11, previously employed for producing each tab cut. This offsetting permits the use of a smaller diameter pin for deflection of the tabs and provide the proper spacing between the pins to hold the tabs in close proximity to one another during bonding. The placement of the pins and tabs in the preferred form of this invention is such that a 45° angle exists between the plane of each tab and the longitudinal direction of the finished board whereby, when the tabs are deflected to form a standing tab structure, groups of four of the tabs each form a box-like structure and present a diamond form extending between the opposing parallel panels of the finished board.

Figure 16 illustrates another apparatus for the assembly of board in accordance with the invention. The apparatus employs two cylinders 31 and 32 which are heated by resistance coils 33, electrical power being

transferred to these coils by brushes 34 of the common rotary commutator type. As cylinders 31 and 32 rotate a conjunction of pins 35 and 30, protruding from said cylinders respectively, deflects tabs 3 and 4 of sheets 1 and 2 causes them to be juxtaposed as at 36 to form an intermediary link as shown at 37.

Figure 17 shows the pins 26 of Figure 14, (or the pins 35 and 30 of Figure 16) and, in an enlarged cutaway view, shows the panels 1 and 2 adjoined with adhesive and held in position at 36 to form an intermediary member formed by the combined tabs.

Figure 18 further illustrates in detail part of the operation of the apparatus of Figure 16. The cylinders 31 and 32 move in the direction of the arrows, causing pins 30 and 35 to substantially meet so as to juxtapose tabs 3 and 4 and accomplish adjoinment at 36. During this closure operation, there is a wiping action as pins 30 and 35 move in counter directions as shown by arrow 37, and this movement squeezes excess adhesive from the space between the tabs, and achieves a secure bonding within the span of angles as shown by the variation of the pin centre lines 39 and 40.

Figure 19 is an illustration of panel 1 and 2 as assembled by the process and apparatus of Figure 14 or Figure 16, with the resultant product having proper closure of tabs 3 and 4 to achieve an alignment and completion of board 41.

Figure 20 is a perspective partially cutaway view of a pair of tabs in accordance with the embodiment of Figures 9 and 10 in which panels 10 and 11 are adjoined to one another by tabs 12 and 13 with a secondary tab 14 provided to be forced through an opening in tab 12 (not shown).

Figure 21 is a cross-sectional view of a hand method of joining the tabs illustrated in Figure 8, 9, 10 and 20. A hand-held pin 51 is utilized to deflect a secondary area tab 14 through an opening 15 in each primary tab 13 after the tabs 12, 13 have been previously hand-positioned relative to one another. The pin 51 co-operates with an anvil-like support provided by a pin 52 held in the opposite hand of the operator and having cut in its surface a suitable relief 53.

Figure 22 illustrates a partially cutaway perspective view of a pair of tabs 12, 13 as assembled by the method of Figure 21. The secondary tab 14 is shown as a single element connection forced through a perforation (not shown) in tab 13.

Changes in the size, shape, angularity and arrangement of the tabs, and the placement of the tabs with respect to the boundaries of the panels utilized can be effected without departing from the scope of the invention as defined by the appendent claims.

Figures 23 to 27 illustrate an apparatus for mass-producing the above described board product. Figure 23 is a schematic plan view of the paper supply portion of the apparatus, comprising two continuous panel or paper stock unwind stations 60 and 61. Paper webs or sheets are drawn from the unwind stations, past guide rollers 62 and 63, by draw roller stations 64 and 65 each of which comprises a two roll set having the web or sheet 66 and 67 passing through the nip of the rollers so as to be drawn from the unwind stations 60 and 61 in the direction indicated by arrow 68.

Figure 24 is a schematic illustration of the cutting portion of the apparatus. Webs 66 and 67 pass through a dual cutting station, in the direction of arrow 68. Web 66 is cut by the upper cutting station, comprising a plurality of pins 72 extending from the surface of a roller 70 and working in contact with the face of a rubber covered roller 71. As the cutting faces of pins 72 cut sheet 66, gearing 72a and 73 transfers the motion of rollers 70 and 71 to similar rollers 74 and 75 which co-act as a lower cutting station to produce a cut pattern in web 67 to match that of web 66.

Figure 25 is a schematic illustration of the next successive portion of the apparatus, adapted to apply adhesive to the cut sheets. Webs 66 and 67 move in the direction of arrow 68 past a single bead application adhesive coating station in which a series of discs of identical diameter form a cylinder assembly 81 which rotates in an adhesive bath 87. The discs are doctored by doctor plate assembly 83 to meter to the surface of web 66 stripes of adhesive for adjoinment of web 66 to web 67, both of which pass through guide roller stations 84 and 85.

Figure 26 shows, in partial cross-section, the cylinder assembly 81 and the discs 86 mounted on said cylinder and immersed in adhesive fluid 87 retained by reservoir 88 to stripe cut web 66 travelling in the direction of arrow 89.

Figure 27 is a schematic view of the next portion of the assembly apparatus. A pair of gauging rollers (not shown) act as lead and guide rolls for two cylinders 92 and 93 that form, in synchronization, a nip containing a pattern of pins coinciding with the tabs of webs 66 and 67. As previously described, closure of said pins produces a bending and adjoinment of the tabs of the webs, with retention in this adjoinment by the adhesive applied by the apparatus of Figures 25 and 26. A downstream drying means is provided wherein forced air, passing over heater resistance coils 94, moves in the direction of arrows 95 to fill plenums 96 and is directed through orifices 97 to impinge upon webs 66 and 67. The air exhausts from these plenums as shown by arrow 98, and thus removes residual moisture associated with the

adhesive application. The perforated configuration of the board achieves maximum efficiency in the drying zone since, during the drying operation, air readily passes through the perforations or openings in the board faces, past the joined tabs, and out of the edges of the board structure.

Figure 28 illustrates a completed board section in perspective and made by the apparatus of Figures 23 to 27. The thickness of the completed board is at least five times as thick as the sum of the thickness of the panels 1 and 2.

The tabs need not be in round form, as depicted in Figures 1 et seq. For example, the length of a tab can be extended beyond the perpendicular bonding area of adjoinment with its opposite tab and can be sufficiently long to attach to the inside plane surface of the opposite panel. In addition, the tab shape can be related to some external latching procedure and, for this reason, an irregularity in the tab contour may be desirable.

Figure 29 is a cross-sectional illustration of a corner construction employing components similar to those of Figure 2 to produce a board 115 which is folded into two orthogonal sections defining a corner. Panels 116, 117 with openings made by bending out tabs and coinciding with those of board 115 are superimposed over the inner and outer sides of the board bridging the corner fold, and are connected to both faces of the board 115 by deflecting the tabs of panels 116 and 117 into the openings in both faces of board 115.

Figure 30 is a perspective illustration of the arrangement described with reference to Figure 29 showing the board 115 with superimposed panels 116, 117. The tabs of the superimposed panels 116 and 117 are deflected into the openings 118 of the boards 115 and are retained in place with or without the use of bonding agents.

Figure 31 is an additional embodiment of a corner connection in which boards 115 and 125 are bridged by a panel 119 that has been shaped to provide spaced tabs 120 that are distorted and bent into openings 107 in the board to retain or connect the boards or to provide reinforcing of a corner.

Figure 32 is a perspective illustration of two tray elements 123 and 124 formed from board assembled from components similar to those of Figure 2. The openings 118 in the upstanding edges of these tray elements are connected by deflected tabs 110 from the plane of tapes 122 that are wrapped around the upstanding edges of the tray elements to retain tray elements 123 and 124 in a parallel relationship to one another and to retain articles of commerce 126 therebetween. Retention is accomplished by the deflection of the tabs 110 into the openings 118.

Figure 33 is a perspective illustration of a curved panel 130 of which the tab placement and spacing causes a curvature when joined with panel 131. Upon completion of the curvature to a full circle, panel 131 is brought to an overlapped position in which tabs 131b are bent into openings of the assembly as are tabs 107. Adhesive bonding is provided in space 131c between the panels, and liner material 132 closes the butt joint 131d of panel 130.

Figure 34 is a perspective illustration of a cylinder configuration of board in which components are combined by tab elements prepared with different hole spacings in panels 130 and 131 respectively so that, when the tabs are connected, the closer hole spacing of panel 130 permits the tab adjoinment to accomplish a circle configuration. An internal liner 132 is added. The overlapping of the panels is illustrated in cutaway 133 to show the overlapping of panel 130 at the abutment line 134 as opposed to the opposite direction of overlap of panel 131 as illustrated by line 135. It is possible to continuously wind and assemble such a form by employing a spiral technique as illustrated by the curve and angle of line 135.

Figure 35 illustrates in perspective and cutaway a tapered bucket, tub or cup-like configuration in which panels are combined using the different tab spacing of Figure 34 but with the spacing being selected to accommodate a taper. The panels 131 and 130 are adjoined in this manner to form a cup having a rolled overlapping seam 136 extending from panel 130 and acting as a drinking or closing lip. The lower edge of panel 131 is also rolled to close the lower end of the board while providing a stop 137 in the bottom of the cup against which a circular cup bottom board 138 rests.

Figure 36 is a cross-sectional view of a ceiling showing fluorescent illuminating fixtures 140 and 141 positioned above a plastics board 142 fabricated from components like those of Figure 2. Air passing from the ceiling plenum is shown by arrows 143 and, due to the perforated nature of board 142, outwardly in varied directions with relation to the board as shown by arrows 144. Sound waves 145 striking the surface of the panel are deflected and attenuated as shown by wiggly line 146. A board according to this invention, when fabricated of translucent plastics, can thus serve as a light transmission means, an air deflection control unit and an acoustical surface.

Figure 37 illustrates in perspective the preparation of components in the assembly of an aero-foil in which a panel 150 is precut to form tabs 151, 152 and 153. These

tabs 151 at one end of the panel are aligned with and adjoin similarly placed tabs 152 at the opposite extremity of the same panel 150, while the tabs 153 attach to tabs 154 of a spar section 155.

Figure 38 is a perspective cutaway illustration showing the assembled aero-foil made from the panel 150 and the spar 155 of Figure 37. As illustrated in Figures 37 and 38, the perforations 151 and 152 have different sizes, to provide cooperating tabs of different sizes and of different angular inclinations between the panels, thereby to achieve a desired contour of the aerofoil and in particular a desired variation in spacing between the panel portions.

Figure 39 is a perspective illustration of tray-like product. The assembled panels have been formed and cut to achieve a product with a contoured configuration, and rigidity is achieved in the assembly by the connection of tabs which link the two panels in various planar relationships to one another. Panels 160 and 161 are joined by tabs 162 of large dimension where the spacing is greater, and tabs 163 of smaller diameter are used where the spacing between the panels is of lesser dimension.

Figure 40 is a cross-sectional view of a die set functioning to connect panels 160 and 161.

Figure 41 is a perspective cross-sectional views of panels like those of Figure 2 in which panels 101 and 102 are enclosed by thin wood laminations 164 and 165. A wood end or edge element 166 is also provided to fully encapsulate the assembled board achieving a rigid structural member capable of use, for example, as a door frame.

Figure 42 is a partially assembled perspective illustration of a board assembled from panels 101 and 102, and associated with overlay panels 166 and 167 having tabs larger than those of the panels 101 and 102. The overlay panels are superimposed on the outer faces of the panels 101 and 102, and the larger tabs extending therefrom are pressed through the tab openings of panels 101 and 102 to increase the strength of the overall structure.

Figure 43 is an enlarged perpective illustration of the arrangement of Figure 42, showing panels 101 and 102 with the overlay panels 166 and 167 in place. Each enlarged opening 168 in the overlay panels forms a relatively large tab 170 which is deflected through a smaller opening 107 causing edge distortion of tab 170 into a channel form 171. Since the length of each tab 170 is greater than the spacing between panels 101 and 102, an additional deflection or bending of tab 170 occurs at 172 to form a parallel tab section which lies against the plane of panel 102 and which is bonded thereto on line 173. Each deflected tab 170 is disposed in facing relation to an interconnected tab pair of panels 101, 102 on the opposite side of each opening 107.

Figure 44 illustrates the first step in a staking operation for interconnecting the tabs of metal panels 101 and 102 like those of Figure 2. The tabs are joined to one another by mechanical reciprocating units 175 and 176 that move into place in the direction of arrows 177 and 178 through openings 107 of panels 101 and 102 to displace tabs 103 and 104 from the planes of panels 101 and 102 into overlapping relation with one another, after which co-axial rods 180 and 181 move within rod sleeve units 175 and 176 to stake the tabs to one another.

Figure 45 is a cross-sectional illustration of the panels 101 and 102 showing the rods 175 and 176 in a finel position preparatory to staking. Coaxial rods 180 and 181 are moved with force in the direction of arrows 182 and 183 causing cutters 185 and 186 pivotally mounted on pins 187 and 188, to move cutting edges against tabs 103 and 104 displacing staked elements 189 and 190 from the plane of tabs 103 and 104 and, in so doing, latching them together. This action is followed by the retraction of rod sleeves 175 and 176 in the direction of arrows 191 and 192 thus completing the staking operation of Figures 44 and 45.

Figure 46 illustrates another apparatus for staking the overlapping tabs of metal panels like those of Figure 2. Machine tool staking components 200 and 201 are moved through panel openings 107 against tabs that have previously been positioned in the overlapping adjoinment relationship previously described.

Figure 47 is a cross-sectional view showing the tool elements 200 and 201 in final position after punching tabs 103 and 104 f panels 101 and 102. The punching operation causes a distortion or deflection 203 and 204 to produce an interlocking of said tabs, after which tool units 200 and 201 are retracted from the hole positions 107 in the direction of arrows 205 and 206.

Figure 48 is a cross-sectional illustration showing how the overlapping tabs of metal panels 101 and 102 can be spot welded together after being properly positioned by tooling like that of Figure 40. Spot welding electrodes 208 and 209 are brought into contact against tabs 103 and 104 at position 210 to cause a bonding or connection by fusing the metal.

Figure 49 is a cross-sectional view of an assembly like that of Figure 2 in which the tabs of panels 101 and 102, previously joined by a spot welding apparatus like that of Figure 48 are subjected to a second spot welding operation in which the extremity of tab 103 and tab 104 is attached to the opposite panel in the plane of said panel. This second operation is effected by the appli-

cation of electrodes 211, 212, 213 and 214, the conductors of which cause a fusing of the metal at positions 215 and 216 to attach the extremity of each tab to the inner face of the opposing metal panel.

The embodiments described can produce a paper board product utilizing extremely heavy paper board materials in the order of 1/16th to 1/4 of an inch in thickness.

Where desirable for acoustic panels for ceilings a soft or semi-soft fire retardant sheet may be used.

WHAT I CLAIM IS:—

1. A product comprising two panels disposed in spaced relation to one another, each of said panels having a plurality of cuts therein defining tabs which are bent relative to said panel to extend toward the other of said panels across substantially the entire space between said panels, pairs of said tabs extending respectively from said panels being disposed in substantially completely overlapping relation to one another, said overlapping tabs being attached to one another to form intermediary members that retain said panels in fixed position relative to one another.

2. The product according to claim 1 wherein said intermediary members are disposed in a plurality of intersecting planes.

3. The product according to claim 2 in which said panels are elongate and the intermediary members are disposed in planes extending at substantially 45° to the direction of length of each panel.

4. The product according to claim 2 or claim 3 wherein said plurality of intermediary members are disposed in angular relation to one another in groups of four bounding volumes between said panels having parallelogram cross-sectional shapes.

5. The product according to any of the preceding claims wherein said tabs have a round configuration.

6. The product according to any of the preceding claims wherein the tabs extend substantially perpendicularly to said panels.

7. The product according to any one of the preceding claims wherein each tab extending from one of said panels is mechanically interlocked to a corresponding tab extending from the other of said panels.

8. The product according to any of the preceding claims in which the tabs in one of said panels are spaced from one another by a spacing which differs from that between the tabs in the other of said panels, whereby said attached tabs retain said panels in a contoured configuration.

9. The product according to any of the preceding claims including an imperofate cover panel fastened to the outermost surface of at least one of said panels and covering the openings resulting from bending the tabs.

10. The product according to any of claims 1 to 8 including a pair of imperforate cover panels fastened one to each outermost surface of each of said panels and covering the openings resulting from bending the tabs.

11. The product according to any f claims 1 to 8 in which a cover panel overlies the outer surface of one of said panels, said cover panel having a plurality of further tabs extending therefrom which are bent at an angle to the plane of said cover panel into the openings resulting from bending said tabs in said one of said panels.

12. The product according to claim 11 wherein said further tabs extend from opposing edges of said cover panel.

13. The product according to claim 11 or claim 12 wherein said cover panel has a plurality of cuts therein defining said further tabs.

14. The product according to any of claims 11 to 13 wherein each of said further tabs has a larger dimension than the openings in said one of said panels resulting from the bending of the tabs therein, whereby each of said further tabs is distorted in configuration as it is forced into an opening in said one of said panels.

15. The product according to claim 14 wherein each of said further tabs is distorted into a channel shaped configuration, the free end of said channel shaped further tab engaging the other of said panels and being bonded to the inner surface of said other panel.

16. The product according to any of claims 11 to 17 wherein each tab in each of said panels is bent about a hinge line disposed at one edge portion of an opening in said panel, each of said further tabs being bent about a hinge line in said cover panel disposed adjacent a different edge portion of said opening in said panel, whereby the plane of each of said further tabs passing through a given opening in said panel is displaced from the plane of the overlapping tabs associated with said given opening.

17. The product according to claim 16 wherein the plane of each of said further tabs is disposed in spaced facing relation to the plane of the overlapping tabs associated with said given opening.

18. The product according to any of claims 11 to 17 wherein said panels are folded about a fold line to define a corner structure, said cover panel briding said fold line and having said further tabs in engagement with openings in said one of said panels on both sides of said fold line.

19. The product according to any of claims 11 to 18 including a further cover panel overlying the outer surface of the other of said panels, said further cover panel having a plurality of cuts therein defining further tabs which are bent at an angle to the plane of

said further cover panel into the openings in said other of said panels.

20. The product according to claim 19 when dependent on claim 17 wherein each of said cover panels bridges said line to reinforce said corner structure.

21. The product according to any of the preceding claims in which at least one of said overlapping tabs is sufficiently long to completely span the space between said panels and engage the inner surface of the opposing panel.

22. The product according to claim 21 wherein the free end of said one of said tabs is attached to the inner surface of said opposing panel.

23. The product according to any of the preceding claims wherein each of said panels is fabricated of paper.

24. The product according to claim 23 including a layer of adhesive bonding said overlapping tabs.

25. The product according to claim 22 wherein said panels and tabs are fabricated of metal, said free end of said one of said tabs being welded to the inner surface of said opposing panel.

26. The product according to any of claims 1 to 22 wherein said panels and tabs are fabricated of metal, said overlapping tabs being attached to one another by a weld joint.

27. The product according to any of claims 1 to 22 wherein said panels and tabs are fabricated of metal, said overlapping tabs being attached to one another by staking.

28. The product according to any of the preceding claims in which the tabs extending from each of said panels are differently dimensioned whereby said overlapping attached tabs retain said panels in varyingly spaced relation to one another.

29. A method of forming a structural member comprising the steps of making cuts in a pair of panels to form a plurality of tab areas in each said panel, each cut leaving an uncut portion in said panel which is adapted to act as a hinge line for said tab area, said cuts producing like patterns of tabs in each of said panels, positioning said pair of panels in spaced, facing relation to one another with said like patterns of tab areas being in substantially opposing relation to one another, bending the tab areas in said panels about their respective hinge lines to form a plurality of tabs which extend into the space betwen said panels, each tab extending from one of said panels being disposed in facing, closely adjacent, substantially completely overlapping relation to a corresponding tab extending from the other of said panels, and fastening each tab extending from said one of said panels to the corresponding tab extending from the other of said panels.

30. The method according to claim 29 wherein the tabs extend in a plurality of intersecting planes.

31. The method according to either claim 29 or claim 30 wherein said cuts are effected to produce differently angled hinge lines in each panel in groups of four hinge lines positioned respectively along the sides of a parallelogram.

32. The method according to any of claims 29 to 31 wherein said panels are of elongated configuration, each of said hinge lines extending at substantially 45° to the direction of length of each panel.

33. The method according to any of claims 29 to 32 wherein each cut partially severs each panel along a continuous line of circular configuration subtending an angle of 180° to 310°.

34. The method according to any of claims 29 to 33 wherein said panels are fabricated of paper.

35. The method according to any of claims 29 to 34 wherein said fastening step comprises applying an adhesive material to the tabs of at least one of said panels.

36. The method according to claim 35 wherein said adhesive is applied subsequent to said cutting step and prior to said bending step.

37. The method according to either of claims 35 and 36 including the steps of drying said adhesive by forcing air past said fastened tabs via the perforations in said panels and through the space between said panels.

38. The method according to any of claims 29 to 37 wherein said positioning step locates said panels in parallel relation to one another.

39. The method according to any of claims 29 to 34 wherein said fastening step comprises cutting the tabs extending from one of said panels to produce auxiliary tabs therein, perforating the tabs extending from the other of said panels to provide openings therein adapted to receive said auxiliary tabs, and forcing said auxiliary tabs through said respective openings.

40. The method according to any of claims 29 to 39 including the step of fastening an imperforate cover panel to the outermost surface of one of said cut panels following said fastening step.

41. The method according to any of claims 29 to 39 wherein an imperforate cover panel is fastened to the outermost surface of each of said panels.

42. An apparatus for joining a pair of paper or fibre board sheets comprising means for making like patterns of plural cuts in each of said sheets, said means being operative to make each cut a substantially round arc extending through an angle of at least 180° and not more than 310° whereby each cut defines a substantially round tab area located

substantially in the plane of said sheet and adapted to be bent out of the plane of said sheet about an uncut portion which acts as a hinge line, means for applying an adhesive material to the tab areas of at least one of said sheets, means for aligning said sheets in spaced substantially parallel relation to one another with the pattern of cuts in each sheet being in opposed relation to the like pattern of cuts in the other of said sheets, and means for bending the tab areas defined by the cuts in said sheets through an angle of substantially 90° to the plane of said sheet and in a direction extending toward the other of said sheets to cause corresponding pairs of said tabs extending from said two sheets respectively to come into overlapping, planar engagement with one another in the region between said spaced parallel sheets and to be bonded to one another by said adhesive material.

43. The apparatus according to claim 42 wherein said cutting means comprises a pair of rollers mounted for rotation adjacent one another, one of said rollers having a plurality of round pins extending from the surface thereof, each pin having a cutting edge and the other of said rollers having a resilient surface positioned for engagement with the free ends of said pins at the nip of said rollers.

44. The apparatus according to claim 42 or claim 43 wherein said means for bending the tab areas comprises a pair of rollers mounted for counter rotation relative to one another, each of said rollers including a plurality of pins extending from the surface thereof, the pins in said rollers being so positioned relative to one another that, during rotati n of said rollers, each pin extending from one of said rollers passes closely adjacent to a pin extending from the other of said rollers at the nip of said rollers.

45. The apparatus according to any of claims 42 t 44 including means for drying said joined sheets comprising means for effecting a forced flow of air past said pairs of tabs via the perforations resulting from bending the tabs in at least one of said sheets.

46. The apparatus according to any of claims 42 to 45 including means for heating said adhesive material to facilitate bonding of said corresponding pairs of overlapping tabs to one another.

47. The apparatus according to any of claims 42 to 46 wherein said means for applying adhesive material comprises means operative to apply said adhesive material in a plurality of parallel stripes.

48. A product comprising interconnected panels substantially as hereindescribed with reference to the accompanying drawings.

49. A method of making a product substantially as herein described with reference to the accompanying drawings.

50. Apparatus for producing the product substantially as herein described with reference to Figures 11 to 28 and 42 to 49 of the accompanying drawings.

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FIG. 1

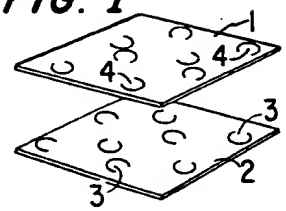

FIG. 8

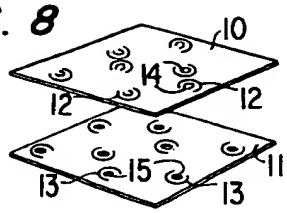

FIG. 2

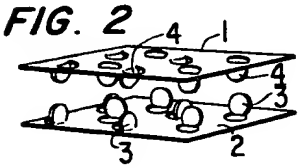

FIG. 9

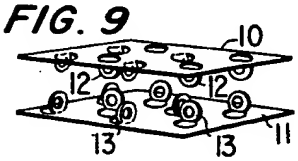

FIG. 3

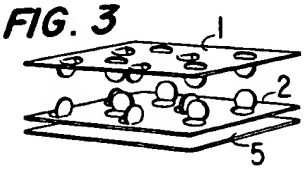

FIG. 10

FIG. 4

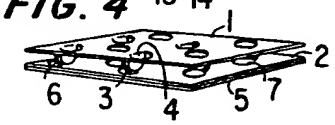

FIG. 5

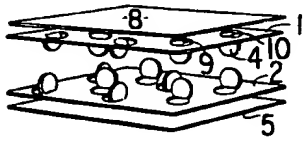

FIG. 7

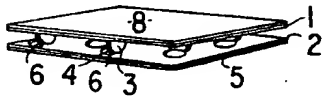

FIG. 6

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FIG. 11

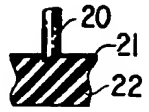


FIG. 12

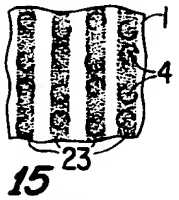


FIG. 13

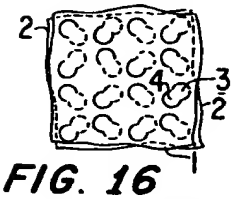


FIG. 14

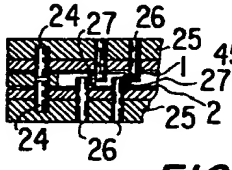


FIG. 15

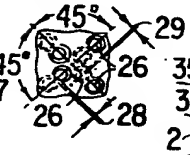


FIG. 16

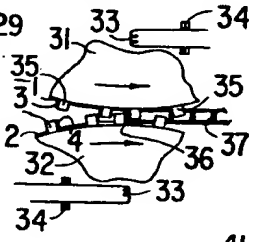


FIG. 18

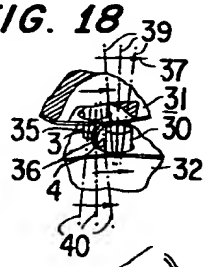
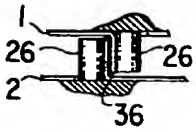


FIG. 17



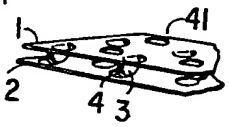
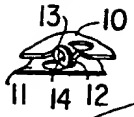


FIG. 19

FIG. 20



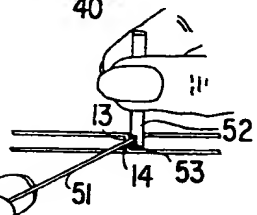
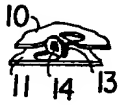


FIG. 21

FIG. 22



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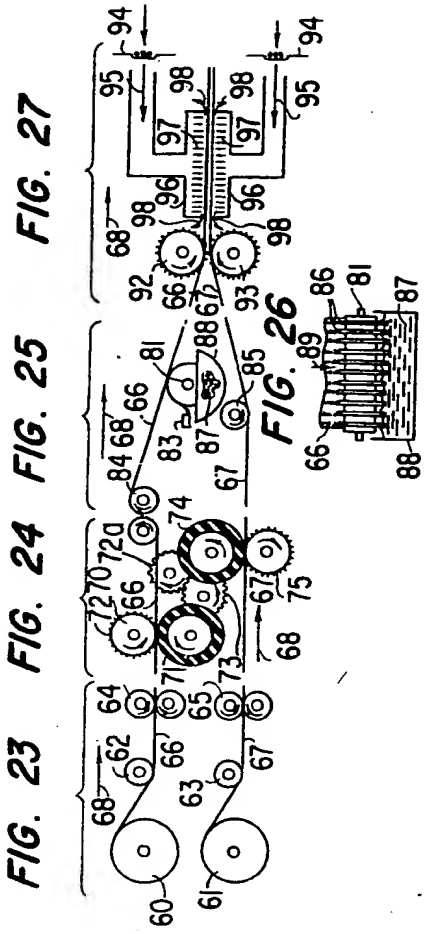


FIG. 23 FIG. 24 FIG. 25 FIG. 27 FIG. 26

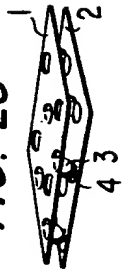


FIG. 28

FIG. 29

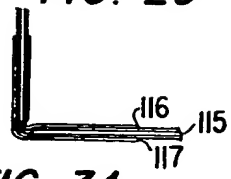


FIG. 30

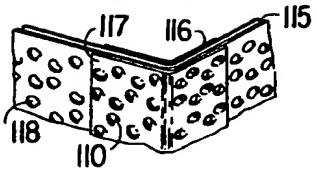


FIG. 31

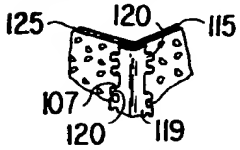


FIG. 32

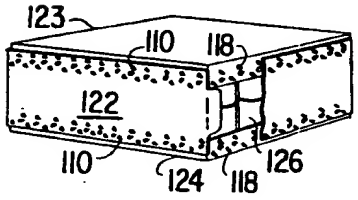


FIG. 33

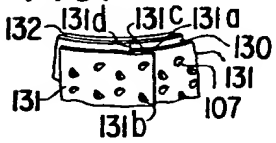


FIG. 34

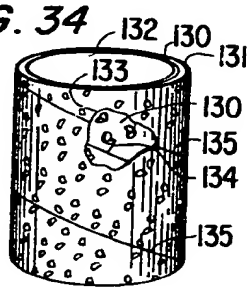


FIG. 35

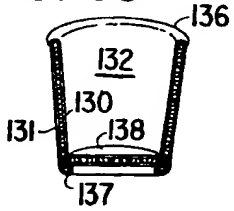


FIG. 36

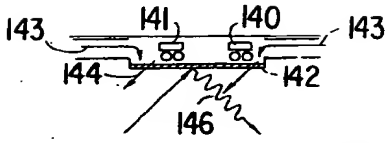


FIG. 37

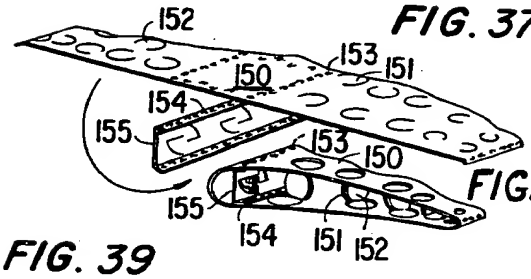


FIG. 38

FIG. 39

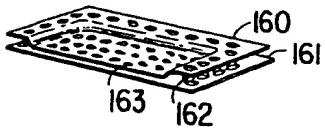


FIG. 40

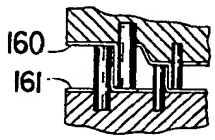


FIG. 41

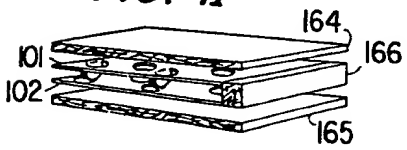


FIG. 42

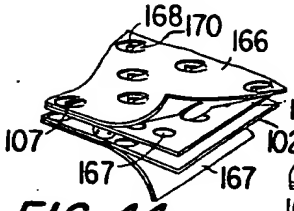


FIG. 43

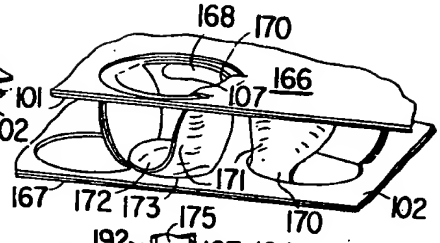
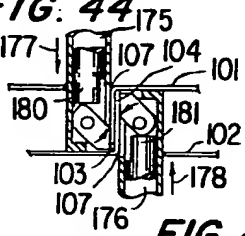


FIG. 44



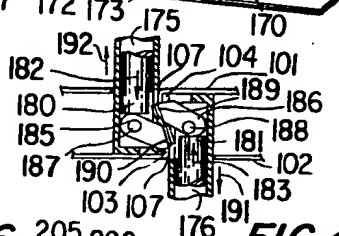


FIG. 46

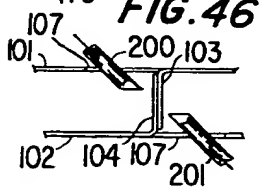


FIG. 45

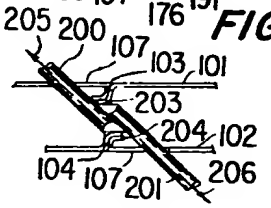


FIG. 48

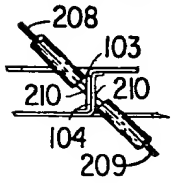


FIG. 47

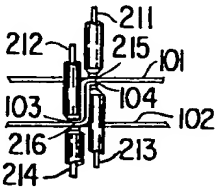


FIG. 49